Fischer-Tropsch Light Synthetic Paraffin Fuels for Fuel Cell Power Generation

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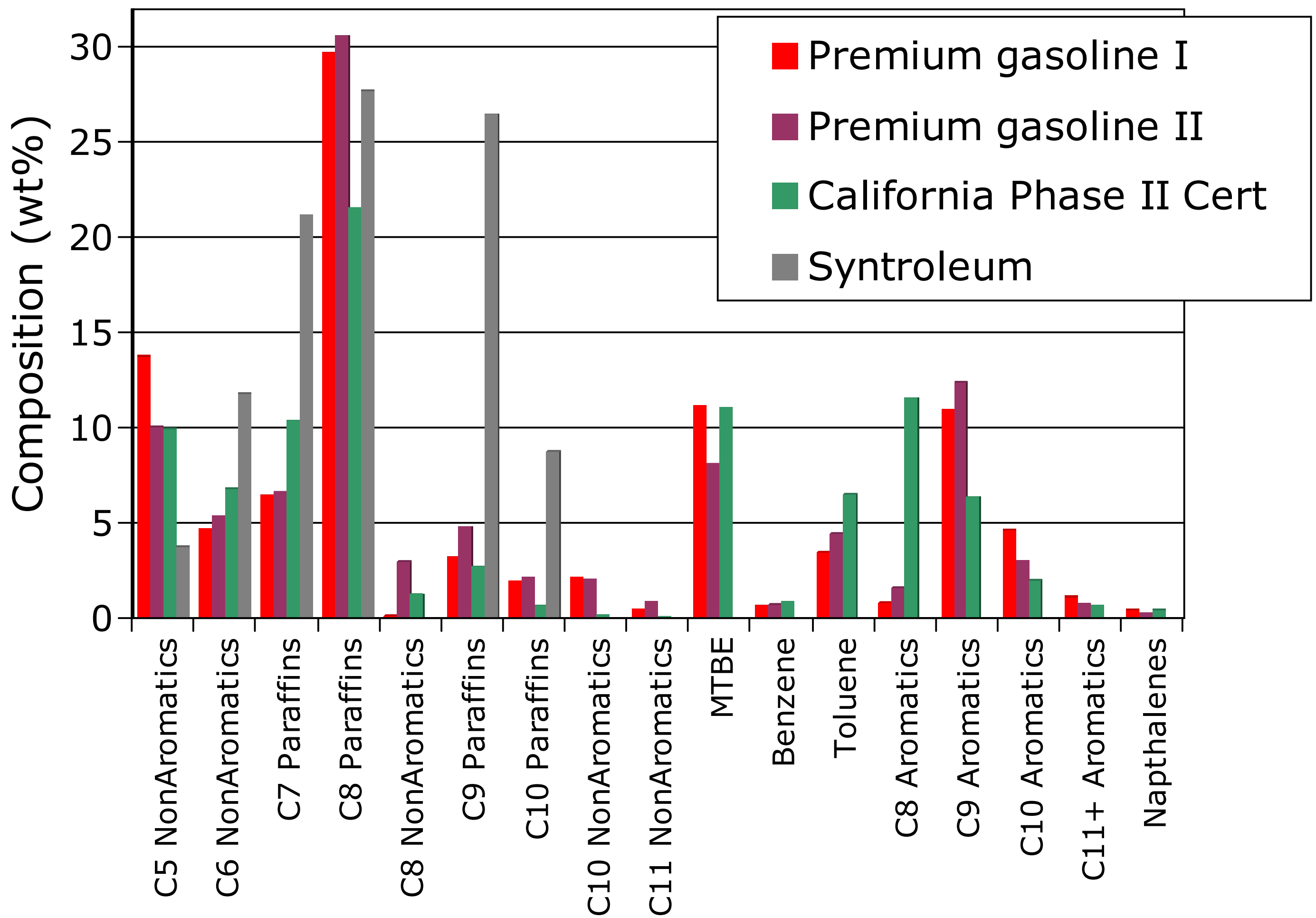
Cobalt-Based Fischer-Tropsch Fuels Are Attractive for Fuel Cells

These synthetic fuels...

- Are similar to petroleum-derived fuels
  - energy density, properties
- Contain no sulfur
  - will simplify fuel processing for fuel cells
- Can use existing refueling infrastructure
- Are uniform in composition
  - predominantly paraffins
- Can be tailored
  - gasoline, diesel, … , designed for fuel cells

Synthetic Gasoline Is More Uniform and Contains No Aromatics



Cobalt-Based FT-Gasoline Is 95% Straight-Chained Paraffins

Gasoline Components	*Wt. %*	*Average Formula*	*FT-Gasoline Components*	*Wt. %*	*Average Formula*
C_4H_{10}	0.7	$\mathbf{C_{7.3}H_{14.8}O_{0.1}}$	C_4H_{10}	0.1	$\mathbf{C_{7.01}H_{15.9}}$
C_5H_{12}	0.1		C_5H_{12}	3.8	
C_6H_{14}	4.9		C_6H_{14}	11.8	
C_7H_{16}	7.5		C_7H_{16}	21.2	
C_8H_{18}	34.3		C_8H_{18}	27.2	
C_9H_{20}	5.6		C_9H_{20}	26.5	
$C_{10}H_{22}$	1.4		$C_{10}H_{22}$	8.8	
$C_5H_{12}O$ (MTBE)	8.3				
C_9H_{12}	12.4				
Others	24.8		Others	0.6	

Conversion Efficiencies Are Affected by Water Requirement

$$\text{Efficiency, \%} = \frac{\text{LHV of H2 in Product}}{\text{LHV of Fuel Feed}} \times 100 = f(n, m, p,)H_f)$$

Water Required = f(n, m, p,)H_f)

Fuel	*Formula*	*LHV*	*To achieve)H_r=0*		*Efficiency*
		kJ/gmol	O_2/Fuel	H_2O/Fuel	% (max.)
Methanol	CH_3OH	638	0.23	0.54	96.3
Ethanol	C_2H_5OH	1236	0.61	1.78	93.6
Gasoline	$C_{7.3}H_{14.8}O_{0.1}$	4440	2.61	9.27	90.8
FT-Gasoline	$C_{7.01}H_{15.9}$	4460	2.57	8.87	91.2

FT-gasoline Yields the Most H2 on the Basis of Fuel Volume, Mass

Compared with methanol, FT-gasoline can produce

- 90% more hydrogen, based on fuel volume
- 111% more hydrogen, based on fuel weight

Fuel	*Formula*	*H_2 Yield (max)*		*CO_2 Yield (min.)*	
		kg/L	kg/kg	kg/L	kg/kg
Methanol	CH_3OH	0.125	0.159	1.08	1.38
Ethanol	C_2H_5OH	0.159	0.204	1.47	1.87
Gasoline	$C_{7.3}H_{14.8}O_{0.1}$	0.224	0.321	2.16	3.09
FT-Gasoline	$C_{7.01}H_{15.9}$	0.235	0.336	2.16	3.08

kg/L = kg of H_2 per Liter of fuel

kg/kg = kg of H_2 per kg of fuel

Methanol Yields the Most H2 on the Basis of Fuel Heating Value

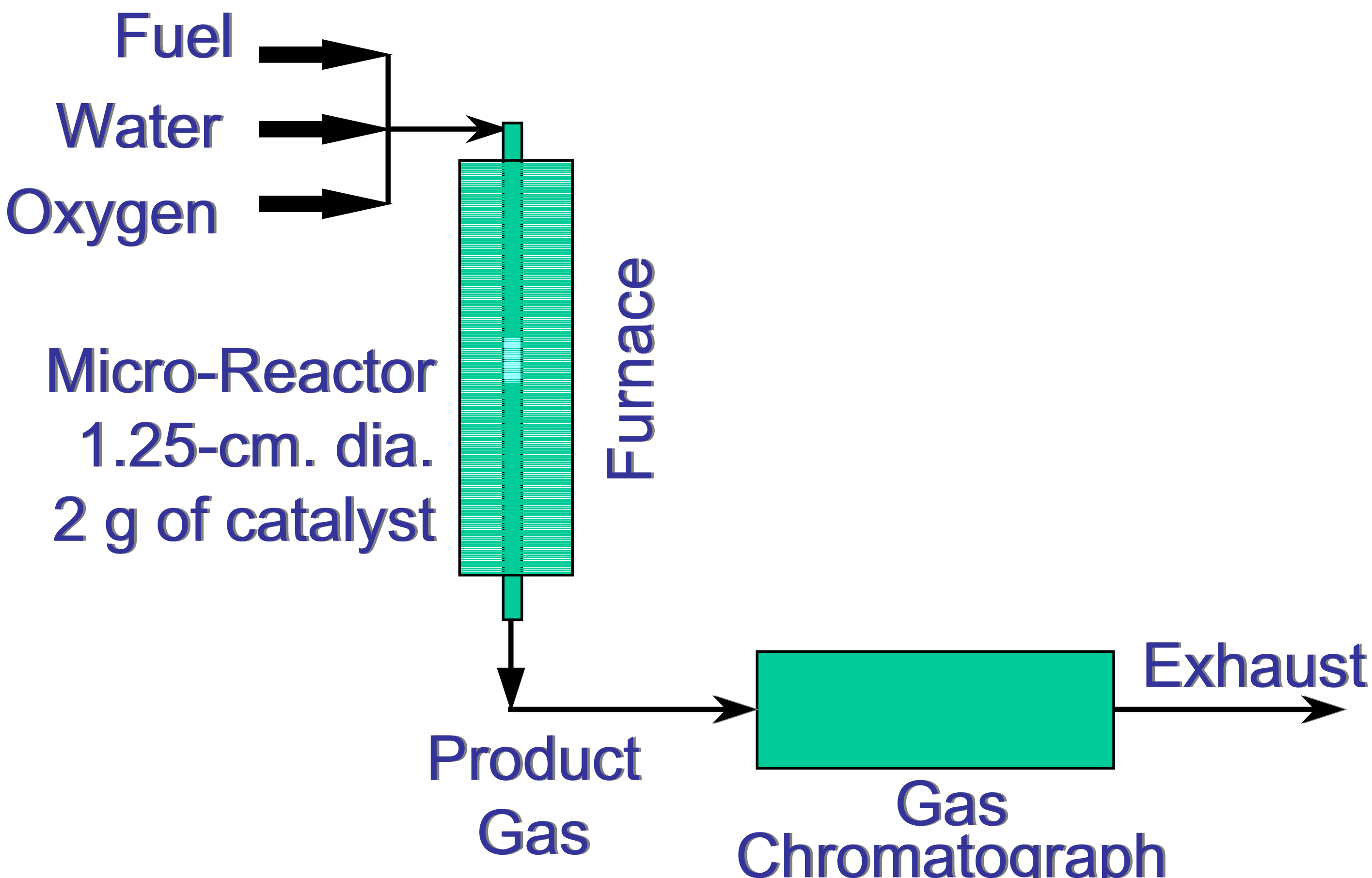
Compared with FT-gasoline, methanol can produce*

- 6.7% more hydrogen
- CO_2 yields are similar

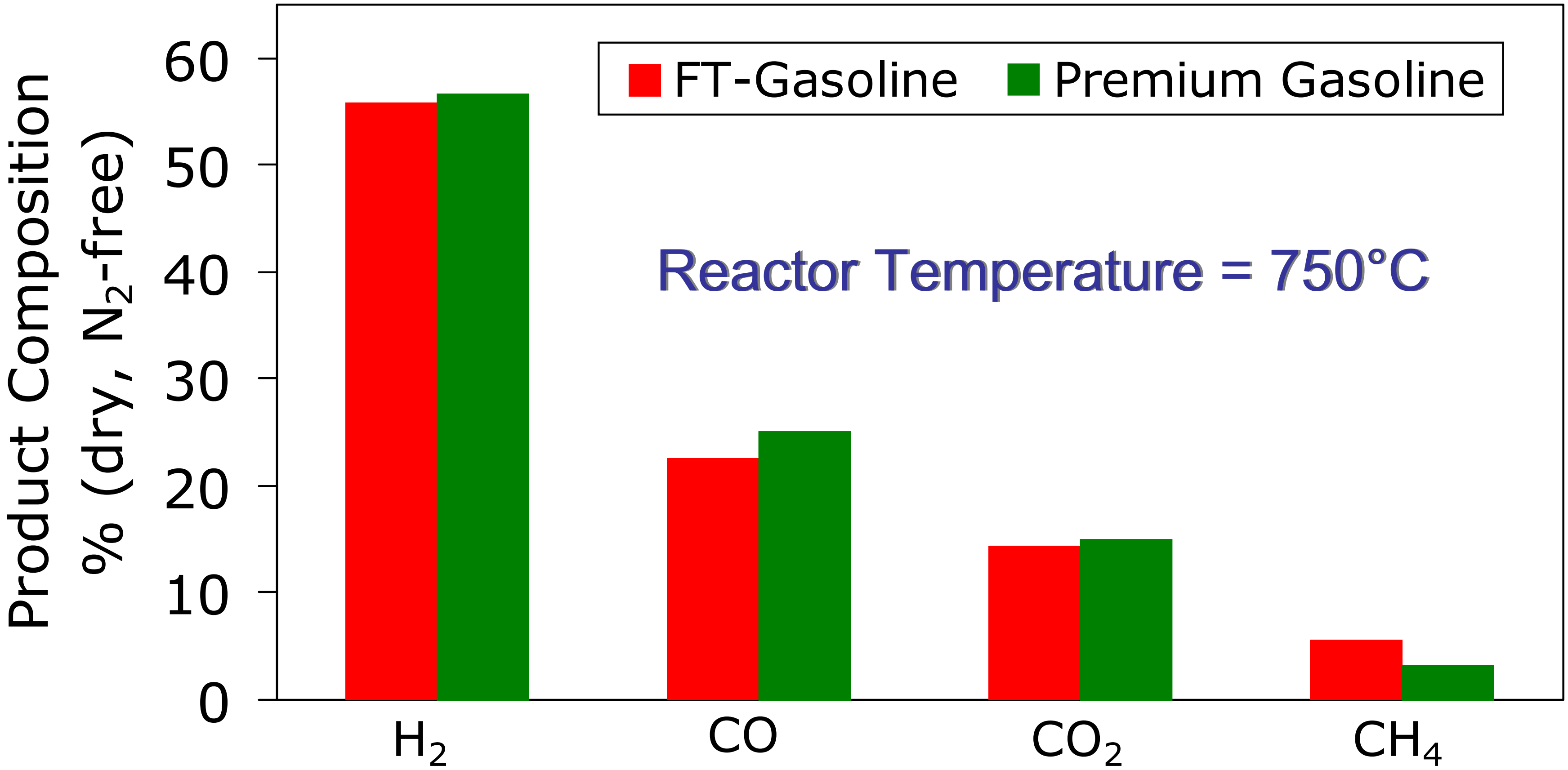
		H_2 Yield (max)	CO_2 Yield (min.)
Fuel	*Formula*	g/MJ	g/MJ
Methanol	CH_3OH	8.0	689
Ethanol	C_2H_5OH	7.7	712
Gasoline	$C_{7.3}H_{14.8}O_{0.1}$	7.5	723
FT-Gasoline	$C_{7.01}H_{15.9}$	7.5	692

* on the basis of the fuel's heating value

Fuel Performance (Conversion, H2 Yield) Is Studied in Micro-Reactors



Reformates from 55% H2 Produced from Premium and FT-Gasoline



Conclusions

- Cobalt-based Fischer-Tropsch fuels are attractive fuels for fuel cells
  - sulfur-free, can use infrastructure, optimizable
- FT-gasolines have high energy densities
  - high hydrogen yields
- FT-gasolines are more uniform in composition than gasoline
  - easier to optimize fuel processing

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